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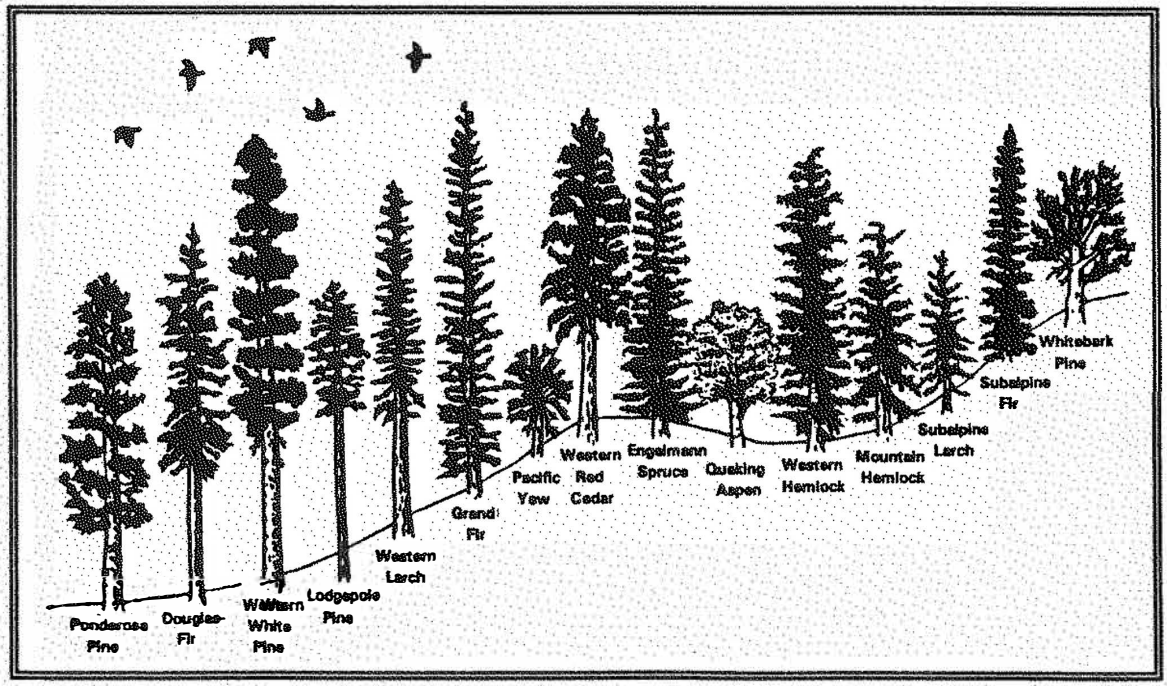
Idaho Forest, Wildlife and Range Policy Analysis Group

Report No. 11 December 1993

Forest Health Conditions in Idaho
Executive Summary

by

Jay O'Laughlin, James G. MacCracken, David L. Adams
Stephen C. Bunting, Keith A. Blatner, and Charles E. Keegan, III



Idaho Forest, Wildlife and Range Policy Analysis Group
Jay O'Laughlin, Director

Idaho Forest, Wildlife and Range Experiment Station
John C. Hendee, Director

University of Idaho

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Executive Summary

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Jay O'Laughlin,[1]
James G. MacCracken,[2]
David L. Adams,[3]
Stephen C. Bunting,[4]
Keith A. Blatner,[5] and
Charles E. Keegan, III[6]

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[1] Dr. O'Laughlin is Director, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, Moscow; a member of the Society of American Foresters; and teaches natural resource policy.

[2] Dr. MacCracken is Research Scientist, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, Moscow; and a member of The Wildlife Society, the Ecological Society of America, the Society for Range Management, and the Northwest Scientific Association.

[3] Dr. Adams is Professor, Department of Forest Resources, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow; a member of the Society of American Foresters; and teaches silviculture and forest protection.

[4] Dr. Bunting is Professor, Department of Range Resources, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow; a member of the Ecological Society of America and the Society for Range Management; and teaches fire and landscape ecology.

[5] Dr. Blatner is Associate Professor, Department of Natural Resource Sciences, Washington State University, Pullman; a member of the Society of American Foresters and the Forest Products Society; and teaches forest finance, harvest scheduling, and natural resource planning.

[6] Mr. Keegan is Director of Forest Industry Research and Associate Professor, Bureau of Business and Economic Research, University of Montana, Missoula; and a member of the Forest Products Society.

A land ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity.

Aldo Leopold (1949)
"The Land Ethic"
A Sand County Almanac

... a consensus exists that western resources generally ought to be developed but that development ought to be balanced and prudent, with precautions taken to ensure sustainability, to protect health, to recognize environmental values, to fulfill community values, and to provide a fair return to the public.

Charles F. Wilkinson (1992)
Crossing the Next Meridian:
Land, Water, and the Future of the West

Regardless of what we are doing, our efforts [to resolve the "logjam" or gridlock in the forests of the Pacific Northwest] must be guided, it seems to me, by five fundamental principles. First, we must never forget the human and the economic dimensions of these problems. Where sound management policies can *preserve the health of forest lands*, sales should go forward. Where this requirement cannot be met, we need to do our best to offer new economic opportunities for year-round, high-wage, high-skill jobs. Second, as we craft a plan, we need to *protect the long-term health of our forests, our wildlife and our waterways*. They are, as the last speaker [Ted Strong, Columbia River Inter-Tribal Fisheries Commission] said, a gift from God and we hold them in trust for future generations. Third, our efforts must be, insofar as we are wise enough to know it, scientifically sound, ecologically credible and legally responsible. Fourth, the plan should produce a predictable and sustainable level of timber sales and non-timber resources that will not degrade or destroy our forest environment. And fifth, to achieve these goals, we will do our best, as I said, to make the federal government work together and work for you.

President Bill Clinton (1993)
Concluding remarks at the "Forest Conference"
April 2, 1993, Portland, Oregon
(emphasis added)

ACKNOWLEDGEMENTS

The individuals listed below reviewed this report. Each was invited to review the entire report, and asked to focus attention on identified portions of the draft manuscript that matched individual areas of expertise. Their contributions are greatly appreciated, as they have substantially improved the content and format of this report. The reviewers provided many insights. However, the reviewers have not approved the contents of this report.

Dr. Mark Brunson
Ecosystem management/
social science
Dept. of Forest Resources
Utah State University

Dr. Richard Everett
Ecosystem management
USDA Forest Service
Wenatchee, Washington

Dr. Greg Filip
Forest pathology
Dept. of Forest Science
Oregon State University

Dr. Jo Ellen Force
Forest policy
Dept. of Forest Resources
University of Idaho

Dr. John Freemuth
Ecosystem management/politics
Dept. of Political Science
Boise State University

Dr. Marvin Henberg
Head
Dept. of Philosophy
University of Idaho

Dr. R. Ladd Livingston
Forest entomology
Idaho Dept. of Lands
Coeur d'Alene, ID

Dr. John Marshall
Tree physiology
Dept. of Forest Resources
University of Idaho

Dr. Penny Morgan
Forest ecology/fire
Dept. of Forest Resources
University of Idaho

Dr. Leon Neuenschwander
Forest ecology/fire
Associate Dean for Research
College of Forestry, Wildlife
and Range Sciences
University of Idaho

Dr. Logan A. Norris
Head
Dept. of Forest Science
Oregon State University

Dr. John Ratti
Wildlife ecology
Dept. of Fish and Wildlife
Resources
University of Idaho

R. Neil Sampson
Executive Vice President
American Forests
Washington, D.C.

The supervisors of the Boise and Payette National Forests were asked to review part of the report, as were. Boise Cascade Corporation resource managers in Idaho. All three organizations were asked to review the entire report. We thank Lyn Morelan, Truman Puchbauer, and Ralph Thier of the USDA Forest Service, and Dave Van De Graaff and Herb Malany of Boise Cascade for their efforts.

During the Assessing Forest Ecosystem Health in the Inland West Workshop held in Sun Valley, Idaho in November 1993, John Thornton of the USDA Forest Service and Dr. Dale Toweill of the Idaho Department of Fish and Game, as well as Ladd Livingston, Ralph Thier, and Lynn Morelan, collaborated to improve the definition of forest health and consideration of ways to measure it. John Thornton and Dr. Al Harvey of the USDA Forest Service reviewed part of the chapter on assessing forest health conditions in Idaho with inventory data and improved it, as did Dr. Wally Covington of Northern Arizona University. We also benefitted from discussions with Dr. Chad Oliver of the University of Washington during the workshop.

Without the cooperation of these and many other individuals this report would be much less than it is. Sharon Gray processed draft after draft of chapter after chapter. Michelle Mazzola improved the readability of the report. Lorraine Ashland and Gerry Snyder prepared several of the figures.

Special thanks to the University of Idaho Society of American Foresters for the cover art.

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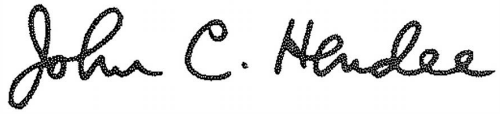
FOREWORD

The Idaho Forest, Wildlife and Range Policy Analysis Group (PAG) was created by the Idaho legislature in 1989 to provide Idaho decision makers with timely and objective data and analyses of pertinent natural resource issues. A standing nine-member advisory committee (see inside cover) suggests issues and priorities for the PAG. Results of each analysis are reviewed by a technical advisory committee selected separately for each inquiry (see the acknowledgements on page *i*). Findings are made available in a policy analysis publication series. This is the eleventh report in the series. The other ten reports are listed in the inside cover.

Forests are important to Idaho for many reasons, and they will continue be. A prolonged drought has subjected forests throughout the Inland West to increased stress, accompanied by insect infestations and disease, creating a situation referred to by many as a forest health crisis. Some feel compelled to take action, others say there is no problem. The advisory committee suggested we undertake this project because of the large number of dead trees in Idaho forests, public controversy about what to do with the dead trees, and concerns about the effects of those actions on other components of Idaho's forest ecosystems.

Forestry research has traditionally reduced forestry problems into ever-smaller pieces. The emerging concept of forest ecosystem health and its implications for managing Idaho's forests for all the benefits Idahoans have come to expect promises to take a broader integrated approach to forestry problems.

The interdisciplinary approach of the Policy Analysis Group gives it the broad perspective needed to address how sustaining healthy forest ecosystems might proceed in Idaho. The topic is complex, and this report is necessarily lengthy. Anything less would do disservice to the emerging importance of forest health and ecosystem management.



John C. Hendee, Dean
College of Forestry, Wildlife
and Range Sciences
University of Idaho

ABSTRACT

If forest health is a statement about trees at risk of mortality from insects, diseases, and wildfire, then much of Idaho's forest land is either unhealthy or on the verge of poor health, especially in the national forests that represent two-thirds of the state's timberlands. Firs are the most prevalent trees in Idaho's forests, which were predominantly pines before European settlers arrived in Idaho. Firs are less resistant than pines to many insects and diseases as well as wildfire. Prolonged drought in southern Idaho has weakened forests, making them even more susceptible to insect epidemics and wildfires. In northern Idaho, root diseases are affecting the growth potential of mature stands. In forests throughout the state, environmental, ecological, economic, and social values are at risk. The situation can be changed by using forest management practices favoring pines instead of firs and reducing competition between trees by thinning, while protecting other forest values. Two obstacles to this course of action are public policy and public trust.

SHORT SUMMARY

Forest health is frequently discussed throughout the United States today, and is usually associated with sustainable ecosystem management. A healthy forest is more likely to be sustainable than an unhealthy one, and thus more capable of meeting the socially-determined needs and aspirations of the present without compromising the ability to meet those of the future. A healthy forest is resilient. It has the ability to respond to natural and human-caused disturbances such as fire, insects, disease, climate change, air pollution, and timber harvesting, and recover relatively quickly.

Are Idaho forests healthy? Judgments about forest health involve different perspectives and values, including political, social, scientific, and professional. Because of these different viewpoints, judgments about forest health have subjective elements. Forests throughout the state are exhibiting increased tree mortality and growth declines, conditions that some people may call unhealthy. Others suggest that this is just one more change in ecosystem dynamics.

Large areas of forest in southwestern Idaho are dying faster than they are growing. Forests in northern Idaho are among the most productive in the nation, but are losing productive potential because of root diseases. Past management practices, specifically timber harvesting and fire suppression, have created different kinds of forests than were here before European settlers arrived in the mid-1800s. Pines have been replaced by firs in dense overcrowded stands. These conditions make the forests susceptible to a variety of insects and diseases and severe wildfires, especially during drought conditions.

What can be done about Idaho's declining forest health? Because of the diverse nature of these forests, there is no single causal variable, and thus no easy fix. Intensive care can help remedy unhealthy forest stand conditions. That is, intensive forestry practices can be used to favor resistant and resilient tree species—pines and western larch. Among other things, intensive forestry practices include thinning dense stands, the use of prescribed fire, and regeneration of more resistant and resilient tree species. The alternative to intensive forestry is reduced productivity, many dead trees, and fuel conditions favorable to large and potentially destructive wildfires. Salvage logging can reduce fire hazard, and recover economic value if done expeditiously.

We know what caused current conditions in Idaho, and we know the remedy. So why don't we do it? Part of the reason is that forests are ecosystems, and we lack complete knowledge of the interactions of forestry practices with wildlife, water quality, and other forest resources. But without trees, there is no forest. There are two related reasons why intensive forestry cannot be implemented: public policy and public trust. Timberlands cover 28% of the state, and more than three-fourths of Idaho's timberlands are managed by public agencies, most of that in the national forests managed by the USDA Forest Service. Public forests, especially the national forests, are governed by policies and regulations that constrain managers from implementing intensive forestry techniques. And there may not be adequate financial resources to carry out the work necessary to change forest conditions. Public trust is intertwined with public policy. The policies implemented by national forest managers were adopted because segments of the public no longer trust the USDA Forest Service to manage the national forests in pursuit of their interests. The problem is less one of people in the agency than it is unclear and sometimes conflicting policy directives.

Idaho forests are in decline, and will continue to decline unless management action is taken. Intensively managed private forests do not exhibit similarly high levels of mortality as nearby public forests. Idaho's federal forests are at risk of insect epidemics in southern Idaho and chronic root disease problems in northern Idaho. Both situations set the stage for catastrophic wildfires that can adversely affect wildlife habitat, water quality, and public budgets for fire control to protect private property adjacent to public forests.

Catastrophic forest mortality (that is, forests

dying faster than they are growing) may or may not be considered a healthy condition, depending on one's values about what forests should be used for. Most of the problem in Idaho is on the national forests, partly because most of Idaho's forests are national forests, but mostly because of the way national forests are managed. National forests comprise two-thirds of Idaho's timberlands and almost three-fourths of the timber volume. Because of that, the health and sustainability of rural communities in the vicinity of Idaho's national forests are at stake. National forests cover 40% of the state, however, 61% of Idaho's national forests are not suitable timberlands, and will likely never be subject to timber harvesting.

Forest scientists have been learning how to protect forests for decades. Forest health is an integrating concept whereby scientists from different backgrounds can work together to develop knowledge in support of management directions that will sustain ecosystems while providing for the full range of forest values society desires. Because there is no agreed upon definition of forest health, we developed one:

> ***Forest health is a condition of forest ecosystems that sustains their complexity while providing for human needs.***

Definitions, however, are not as important as the concerns they represent. Forest health is part of the bigger idea of managing forest ecosystems in a sustainable manner, which includes producing sustained yields of commodity and non-commodity values. This is a new way for resource managers and researchers to view their professional responsibilities. Resource managers and scientists are working hard to develop forest health and ecosystem management strategies, but such efforts alone will not be enough. Resource professionals must work with the public to find out what uses and conditions of the forests are socially acceptable. Only when they know what people will accept can resource managers apply research-based knowledge to sustain long-term forest health and productivity and thus provide forest ecosystems that sustain the conditions and uses that people desire.

Forest health is a useful communication device for relating forest conditions to something people understand, thus attracting their attention to management problems and inspiring them to work toward socially desired solutions. Forest health focuses attention on: [1] the prevention of socially undesirable forest conditions by integrating the various concerns of protecting the forest from insects, diseases, and wildfire in an ecological framework; and [2] the restoration of socially desired forest conditions. Forest health is important by itself and is imbedded in ecosystem management policies. Much work still needs to be done to develop and implement the ecosystem management concept, especially in the social dimension. To be successful, forest health and ecosystem management strategies need public support, and that will come only with effort.

Relationship of Executive Summary to Complete Report

This Executive Summary of Report No. 11, Forest Health Conditions in Idaho, is published separately from the complete report, which consists of 17 chapters and exceeds 200 pages. This Executive Summary appears in the complete report as **Chapter 1. Summary and Overview**. Figure 3 and 5 in this Executive Summary appear in later chapters in the complete report. Cross references to the 17 chapters in the complete report have been deleted in this Executive Summary. A condensed version of the Table of Contents to the complete report is included in this Executive Summary as an **Appendix**. The complete report is available from the University of Idaho's Forest, Wildlife and Range Policy Analysis Group, Moscow, ID (208-885-5776; FAX: 208-885-6226), as are the reports listed on the inside cover.

INTRODUCTION

Forest health reflects many concerns about the sustainability of forest ecosystems. Forest health includes the ability of a forest to recover from natural and human-caused stresses or disturbances, including fire, insects, diseases, climate change, air pollution, and timber harvesting. The principal applications of the forest health concept are in integrating knowledge about forest protection, and communicating forest management concerns to the public.

This introduction explains (a) the purpose and organization of the report, (b) the somewhat controversial linkage of forest health and forest management, and (c) why basic questions about forest health are difficult to answer. Following the introduction, an overview of the entire report is provided, beginning with a discussion of the timeliness of forest health concerns in the Inland West. Because the report focuses on Idaho, a brief section describing Idaho's forest resources is provided. An explanation of how and why we developed our own definition of forest health is followed by a section on problems with measuring forest health. Then the major findings of the report are presented in a bullet list. The overview concludes with sections replying to each of the two focus questions that guided our analysis.

Purpose and Organization of Report

Our task, as developed by the Policy Analysis Group's Advisory Committee, was to develop replies to two focus questions: [1] Is there a forest health problem in Idaho? and [2] What can be done to either treat the forest health problems that exist, or prevent forest health problems from occurring? Because forest health is an emerging concept, replies to these questions should be considered starting points for developing a deeper understanding of the issues, rather than definitive final answers.

The report is divided into four parts, each consisting of at least two chapters. The organization and content of the chapters follows the purpose of the report. We quickly discovered that forest health has not been adequately defined or measured. Part I of the complete report defines forest health. Our definition was developed from ecological concepts and social concerns, including various perspectives on forest health, concerns about ecosystem integrity, and scientific perspectives on whether or not forest ecosystems may be considered healthy.

Part II of the complete report reviews the ecological and managerial factors affecting forest health, beginning with an overview of the role of drought, insects, diseases, nutrition, air pollution, animal damage, past timber management practices, and fire suppression. Fire has important ecological functions in Idaho forests and excluding fire from performing these roles has management implications. One of them involves what to do with dead and dying timber to reduce the risk of catastrophic wildfire. Salvage logging controversies are examined, including the economic, social, environmental, and ecological issues. The relationship between wildlife and forest health is covered. The linkage between forest health and the developing concept of ecosystem management, which has healthy and sustainable forests as an associated goal, is examined. The state of knowledge regarding hazards and risks associated with forest ecosystem health management is reviewed. The discussion of general forest health management and policy concludes with a focus on existing and proposed forest policies that deal specifically with forest health.

Based on the complex of underlying factors affecting forest health described in Part II, in Part III of the complete report we review how it might be possible to measure forest ecosystem health and use available data to analyze forest conditions in Idaho. In Part IV, ecological knowledge and resource management approaches to forest health are assembled in case study formats. The process of succession in ponderosa pine and western white pine forests, historically the most important forests in Idaho, is presented. Forest health problems and management responses by public and private organizations

in southwestern Idaho are analyzed. Because forest health is an emerging concept, we conclude the complete report by pointing out future directions that might lead to a better understanding of forest conditions and subsequent development of effective and socially acceptable resource management strategies to promote healthy forests.

Forest Health and Forest Management

The forest health concept may be most useful as a communications device. Its primary value is to focus attention on how forest ecosystems should be managed. People can easily relate to the notion of sick or unhealthy forests. The implication is that an unhealthy condition should be avoided. Unhealthy forests will not provide a full range of goods and services or environmental values, and most people feel unhealthy conditions should be improved upon. Some people, however, dispute the idea that management can improve on nature, and believe that because they are natural processes, insects, diseases, and fires should be allowed to operate without human intervention, no matter what the consequences.

If people could come to an agreement on what a forest should or should not be used for, resource managers could design programs and implement projects to achieve those ends. These actions can be designed to avoid unhealthy conditions and promote the ability of a forest to respond to changing environmental conditions and natural or human-caused disturbances and stresses in ways consistent with management objectives.

On public lands, it is exceptionally difficult to determine what the appropriate goals or objectives for forest management ought to be, and who should determine them. Forest health is related to ecosystem management, now the guiding philosophy for most federal forest lands. On state and other public forest lands, forest health is an appropriate consideration as programs to achieve the goals and objectives for those lands are planned and implemented.

Private forest landowners also might consider whether or not their actions promote forest health. More than 70% of the nation's timberlands are privately owned, and their role in providing public benefits will continue to be an important forest policy consideration, as it has always been. The goals and objectives for the use and management of private forests are determined by private property owners.

Regardless of ownership, the health condition of a forest makes a difference to managers charged with providing the many and diverse benefits from forests that society desires. A healthy forest is resistant to the effects of low levels of disturbance. A healthy forest is also resilient, that is, it can recover from the effects of natural or human-caused disturbances more rapidly than an unhealthy forest. A healthy forest is better able to respond in an orderly way to change. Environmental conditions such as temperature or precipitation will change and so will forests. Management goals will change as people decide they want something different from the forest.

Focus Questions

Two questions frame our discussions of forest health: [1] When is a forest healthy or unhealthy? [2] What can be done to make forests healthier? These questions apply to forests everywhere and are similar to those asked by the PAG's Advisory Committee in relation to Idaho's forests.

[1] When is a forest healthy? Forest health concerns are relatively new, which greatly inhibits a simple response to this question. Recent federal laws mandate forest health monitoring. Eventually monitoring can provide objective data to help answer the "healthy" question. When that happens, scientists can develop an objective assessment framework to evaluate the data. Neither the data nor the analytical framework have yet been developed.

When describing the National Forest Health Monitoring Program, the USDA Forest Service (1992, emphasis added) said, "Although forest condition can be specified and measured objectively, forest health carries an element of subjectivity, as it is a value

judgment." However, forest health need not be a subjective value judgment. U.S. Environmental Protection Agency scientists stated that some day objective criteria might be developed to reflect important forest ecosystem characteristics and human desires. Several such criteria have been identified, but none are ready to implement (Riitters et al. 1990).

Replies to the healthy/unhealthy question are based on social as well as ecological perspectives, including perceptions of what a forest is. A forest is an ecosystem with woody vegetation as its defining characteristic. Because a forest is an ecosystem, components other than trees or groups of trees (stands) need to be assessed to make judgments about forest health. The appropriate mix of these components as measures of forest health has not been determined. Judgments as to whether or not a forest ecosystem is healthy remain subjective, even though the condition of individual components may be described objectively. Concepts such as ecosystem integrity and balance are not measurable, and therefore not useful in judging forest health.

[2] What can be done to make forests healthier? Like the healthy/unhealthy question, this is a new concern in forestry. Replies to this question are related to what forests should be used for, and thus involve the same forest management and policy problems our society has been wrestling with for more than a century. Clawson (1975) phrased the problem well in the title of his instructive policy analysis text—*Forests for Whom and for What?*

How can forests be managed to reduce not only the effects but also the occurrence of undesirable disturbances? How should forests be managed after disturbances have killed trees? These are not new questions in forestry. Considerable management effort and research has been directed at them for more than a half-century under the general topic of forest protection. Problems associated with present forest conditions are partly a result of past protection efforts, especially wildfire suppression that has kept fire from performing its natural role, with subsequent ecological effects and management consequences. We have learned much about forest protection, but the knowledge is only now being organized and integrated in the context of forest health.

OVERVIEW

The emphasis on forest health arose in the 1980s as forests were affected by unexplained stress factors possibly linked to air pollution in the Northeast, the Appalachians, and Southern California; and as forests suffered the effects of fire, insects, and diseases accompanying prolonged drought in California and the Inland West. More emphasis is needed, because a significant increase in forest mortality (24%) was reported nationwide between 1987 and 1991, with increased mortality in all regions of the country and on all types of forest ownerships (Powell et al. 1993).

Forest Health Concerns in the West

Forest conditions in the Inland West have drawn national media attention in the *Wall Street Journal* (Richards 1992) and elsewhere. A year before he was named Chief of the USDA Forest Service in November 1993, Jack Ward Thomas told the *Washington Post*, "If we weren't blathering about old growth and owls, [forest conditions in the Inland West] would be the hottest story in forestry" (Gray 1992).

Dr. John Osborn (1991)—a Spokane, Washington physician and energizing force of the Inland Empire Public Lands Council, a citizen conservation group—warned of potential catastrophe from an owl-driven shift in the Forest Service's timber program from western Oregon and Washington to the eastern portions of those states, a region often referred to as the "eastside" of the Cascade Mountains. Osborn said the eastside forests in the Blue Mountains are in a "state of biological collapse" caused by decades of chemical application, fire suppression, and logging. John Butruille—who until his recent retirement was the regional forester in charge of national forests in Oregon and Washington—agreed, and said eastside forest ecosystems are

"unraveling" (Durbin 1991). However, others view these conditions as but one more step in an eternity of changes, and say these ecosystems are correcting past man-made mistakes.

These concerns in the Blue Mountains led to the formation of a multi-agency organization called the Blue Mountains Natural Resources Institute. One result is a variety of publications, some describing forest health problems (Gast et al. 1991, Quigley 1992) and others proposing solutions (Wickman 1992, Mutch et al. 1993).

President Bill Clinton convened a one-day "Forest Conference" in Portland, Oregon on April 2, 1993, to fulfill a campaign promise. Federal forests west of the Cascade Mountains and in Northern California provide habitat for the threatened northern spotted owl, and plans for timber harvests in these forests had been suspended by judicial injunction. After listening to several dozen people address issues related to old-growth forest preservation and curtailed timber harvests, President Clinton directed his executive agencies to come up with a solution to the problem within 60 days. A task force called the Forest Ecosystem Management Assessment Team (FEMAT) was formed under the leadership of Jack Ward Thomas. Although the main focus of FEMAT was on old-growth forest ecosystems and spotted owls, some effects have spilled over to eastside forests.

Part of the FEMAT plan (USDA Forest Service 1993c) looked at conservation strategies for a diverse variety of animals inhabiting the same ecosystem as the spotted owl, including salmon. Three salmon stocks are listed as threatened or endangered and subject to the Endangered Species Act of 1973, as is the northern spotted owl. Other salmon stocks in the region are imperiled and could be listed in the near future. The three listed salmon stocks pass through portions of westside and eastside forests as they navigate the Columbia and Snake River system on their to and from spawning grounds in Idaho. Thus Idaho forests are linked to ecosystem management concerns driven by the spotted owl.

An interagency effort called PacFish (Pacific Fisheries) was initiated more than two years before FEMAT, and focused exclusively on management guidelines for riparian and upland habitat adjacent to salmon-bearing streams throughout the Pacific Northwest, including the Columbia and Snake River system. PacFish and FEMAT salmon habitat recommendations are closely linked.

Requests by U.S. Congress members in 1993 created two parallel efforts to assess the health of eastside forest ecosystems, but neither included Idaho. The first assessment was requested by Speaker of the House Thomas Foley (D-WA) and Senator Mark Hatfield (D-OR), and resulted in the 5-volume Eastside Forest Ecosystem Health Assessment (Everett et al. 1993).

The second eastside assessment was requested by seven other members of Congress and asked scientific societies—The Wildlife Society, American Fisheries Society, and Ecological Society of America among them—to make recommendations on how eastside forest ecosystems should be managed. According to the *Journal of Forestry* (1993), the resulting product emphasized protecting the "health and integrity" of regional biotic elements as well as the processes on which they depend. Interim findings were reported in late 1993, and included 11 recommendations. Specific prohibitions and preventative measures were recommended for conserving eastside old-growth forests and riparian areas. Two panels were recommended, one to establish long-term forest health management guidelines, another to develop a strategy for ecosystem and regional landscape restoration (*Journal of Forestry* 1993).

Management changes in the Blue Mountains, other eastside forests, and Idaho are sure to follow in the wake of national attention focused on the situation. The Blue Mountains ecoregion includes portions of the Boise and Payette National Forests in southwestern Idaho. These Idaho forests have problems similar to those in the Blue Mountains. A forest health management strategy is being implemented in the Boise National Forest because of elevated mortality levels from insect outbreaks and severe

wildfires associated with six years of drought conditions that began in 1987. During 1992 and 1993, the Boise National Forest met its annual allowable sale quantity of timber almost exclusively with dead trees.

(**Note:** ecoregion, allowable sale quantity, and many other technical terms are defined in the **Glossary** section at the end of this Executive Summary.)

Idaho Forests

Idaho forests, especially those in the northern part of the state, are among the most productive timberlands in the nation (Wilson and Van Hooser 1993). These forests contain a diversity of tree species (Figure 1), as most of them occupy mountainous terrain. This diversity is illustrated on the cover of the report and graphically portrayed in Figure 1. Timberlands occupy 28% of the state's land area, and are defined as forest lands that can produce 20 cubic feet of wood fiber per acre per year and have not been legally or administratively withdrawn from timber harvesting. In other words, wilderness and other reserved areas are not considered timberlands. As illustrated in Figure 1, Douglas-fir and true firs (primarily grand fir) now account for almost half (48.9%) of the growing stock volume on Idaho's timberlands. Three species of pine comprise slightly more than one-fourth (27.6%) of the forest volume. A variety of other softwood (or conifer) species compromise the remaining one-fourth of Idaho's forests. Hardwoods (almost all cottonwood and aspen) are only 1.5% of Idaho's forest volume (Figure 1).

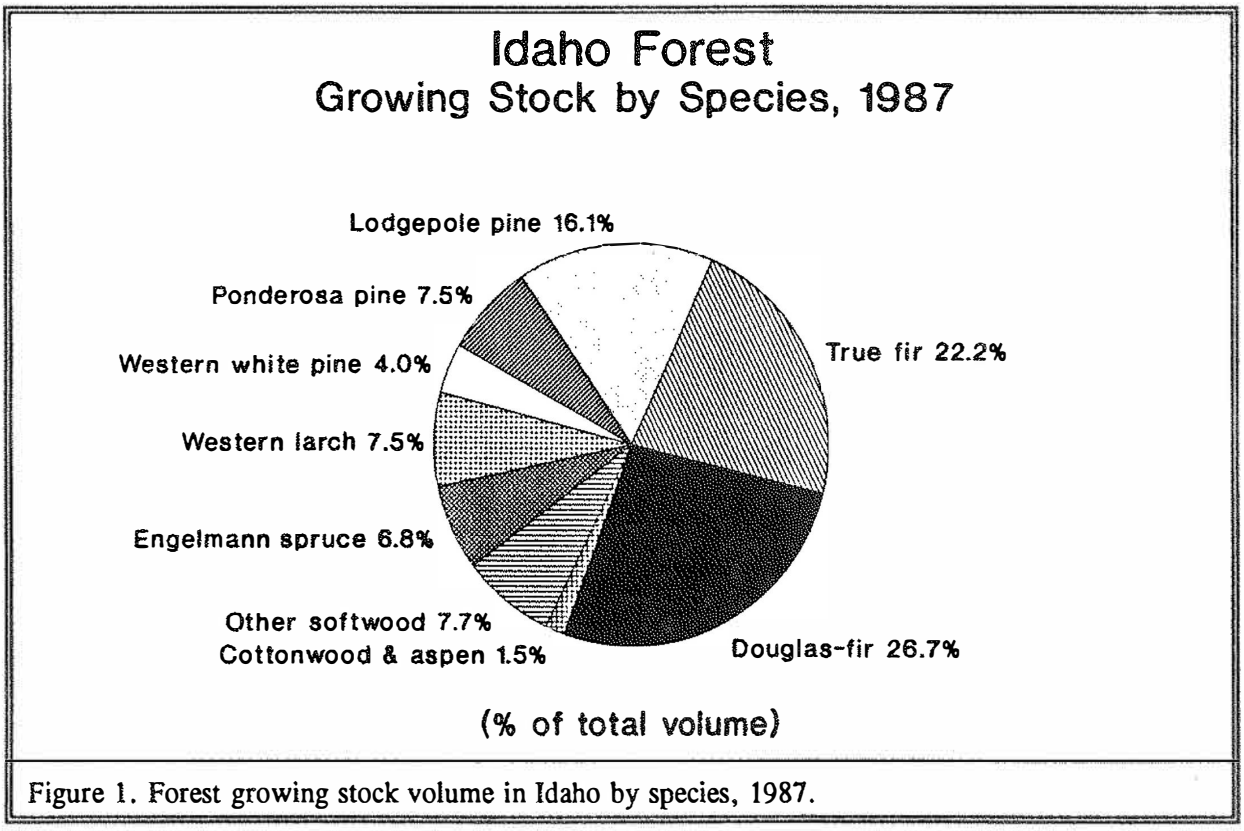


Figure 1. Forest growing stock volume in Idaho by species, 1987.

Source: From data in Waddell et al. (1989).

As illustrated in Figure 2, the ten national forests in Idaho contain about two-thirds (67%) of the timberlands and almost three-fourths (73%) of the forest growing stock. National forest lands identified as suitable or tentatively suitable for timber production represent only 39% of the national forest land area in Idaho.

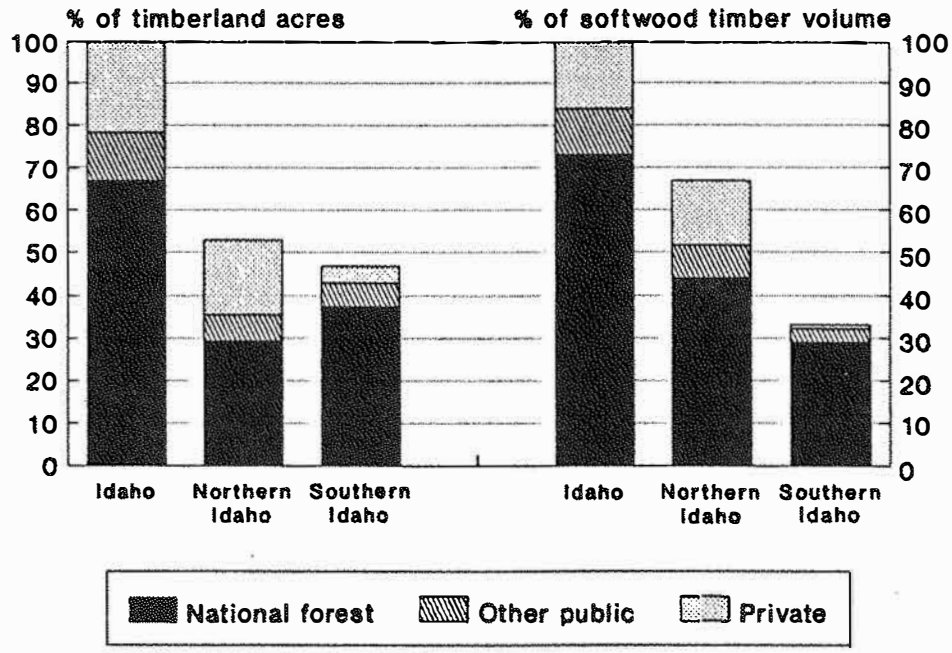


Figure 2. Timberland acres and forest growing stock volume in Idaho by ownership category and distribution in northern and southern Idaho.

Source: Compiled from data in Waddell et al. (1989), Waddell (1992), Wilson and Van Hooser (1993) and individual national forest land and resource management plans.

The rest of the national forests are not considered suitable for timber production for physical, environmental, social, legal, or administrative reasons. In total, all national forest lands cover about 40% of Idaho. No other state comes close to having such a large percentage of its lands in national forests; Oregon ranks second with 25%.

Timberland acreage is almost evenly divided between northern (53%) and southern Idaho (47%), with the Salmon River the dividing line. Average precipitation is higher in the north, enhancing forest productivity. The distribution of forest growing stock reflects this, with two-thirds (67%) of it in northern Idaho and one-third (33%) in southern Idaho (Figure 2). The three national forests in northern Idaho and the seven in southern Idaho are administered by two different regional offices of the USDA Forest Service, the Salmon River again the dividing line.

What is Forest Health?

Discussions of forest management policy in the western states now routinely include concerns about forest health. How can you tell if a forest is healthy or not? No widely accepted definition of forest health exists (Riitters et al. 1990). Until forest health is adequately defined and measurement standards developed, it is difficult to say if a forest is healthy or not.

As a starting point, the Random House (1971) unabridged dictionary provides four definitions of health. All but one applies to the general condition of the human body and mind. The fourth and broadest definition of health is "vigor; vitality: *economic health.*"

We synthesized a definition of forest health after reviewing what is known about the

concept, and how others have described, defined, or used the terms forest health, ecosystem health, and forest ecosystem health. Because a widely accepted definition is lacking, we developed one:

> ***Forest health is a condition of forest ecosystems that sustains their complexity while providing for human needs.***

We began the review and synthesis with various perspectives on forest health and then focused on the emerging concept of ecosystem health and how it relates to human health. The scientific merit of various terms associated with forest health were also addressed; for example, "catastrophe" has a scientific meaning, and "balance of nature" does not. "Resilience" and "sustainability" often are used with forest ecosystem health, and their meanings were examined. These concepts are difficult to measure, but convey important meanings.

Forest health judgments carry an element of subjectivity, even though the condition of various forest ecosystem components such as trees, water, or wildlife can be measured objectively. How those components can be assembled to assess forest ecosystem vigor, vitality, or health as an objective measure is a difficult and uncompleted task.

Forest health is a controversial topic, especially when salvage logging of dead and dying timber is involved. In the USDA Forest Service's (1988) first attempt at a strategic plan for forest health management, the nature and importance of socially perceived problems was addressed:

> Forest health is a complex subject with both real and perceived problems which can arouse strong emotions. Such problems justify nationwide concern. The actual problems are the product of events occurring over a long period of time. The perceived problems reflect an incomplete understanding of forest ecosystems, the biological processes operating within them, and alternative views of the purposes to be served by the forest.

Even with complete understanding of ecosystems, controversies would prevail because of the different perceptions people have about the purposes and uses of forests.

A political commentator in the nation's capital (Swisher 1992) described social problems with forest health succinctly: "'Forest health' has become a buzzword among timber state lawmakers, but the sound grates on the ears of environmentalists like a chain saw." Wickman, a USDA Forest Service entomologist, warned that forest health "is an ambiguous buzz word and as such is an over-used and misused anthropomorphic catchword" (quoted in Osborn 1992). Despite these attempts to preempt the term, forest health discussions persist.

Our forest health definition attempts to reduce ambiguity. We found evidence that some environmentalists recognize the serious forest health problems in the Inland West, which blunts the sharp criticisms above. Although the analogy with human health is imperfect, forest health can be an effective communications tool.

When is a Forest Healthy?

Forest health is an elusive, yet useful, concept. Forest health provides a medium for discussion of forest conditions relative to human needs and desires, and a framework for measurement of ecosystem indicators that can be used to assess general ecosystem condition or health. Although individuals may come to similar conclusions about the condition of a single ecosystem component using an objectively measured indicator, the value-based aspects of forest health make objective measurement difficult and ensure recurrent debates.

Two approaches for judging the health of a forest can be used as a starting point. The first is to focus on forest management objectives, the second is to focus on forest ecosystem function (Monnig and Byler 1992). The first approach includes the full range of forest values people feel are important. The second includes facts as to how a forest works, or how a forest ecosystem functions. This second approach can also describe what people think a forest should be, thus making the maintenance of functional ecosystems an

objective of management. Two important points follow: [1] both approaches are necessary and must be linked together in any scheme for sustainable ecosystem management, and [2] both approaches involve the opinions and values of people, making social concerns obligatory considerations for forest health and sustainable ecosystem management.

Management-oriented approach. According to the USDA Forest Service (1988, 1993b), "an unhealthy forest inhibits managers from achieving objectives; a healthy forest does not pose such obstacles." A healthy forest may not be insect-free or pathogen-free, but sufficiently free of pest damage to meet management objectives (Byler and Zimmer-Grove 1991). Furthermore, a forest can be maintained in such a condition that it will meet the objectives of future generations, which may be different from today and require maintaining various options for the future.

One challenge raised by this objective-oriented definition is that objectives must reflect limitations posed by ecosystem characteristics or properties. Another challenge is that management to achieve objectives requires a clear and explicit statement of objectives so managers know whether they are on target. Much of the forest policy debate about forest management stems from disagreement over management objectives, particularly on public forest lands. For national forests managed by the USDA Forest Service, this debate centers around the ambiguities of "multiple use" management (see Chapter 13 in Cubbage et al. 1993). For state forest lands in Idaho, debate over objectives centers around the purposes of the federal land grants to Idaho at the time of statehood (see O'Laughlin 1990).

For private lands, the management objectives debate is over the appropriate role of government in defining public benefits from private lands and the use of various tools for encouraging or discouraging actions by private landowners. Private property rights are exclusive but not absolute, as government reserves certain property rights in order to protect public values (Barlowe 1978). This is a contentious point today as forest policy discussions focus on how to sustain a wider array of values than in the past, including clean water and habitats for imperiled wildlife.

Ecosystem-oriented approach. According to Monnig and Byler (1992), this approach means that a forest in good health is a "fully functioning" community of plants and animals and their physical environment; or as they said, "an ecosystem in balance." Some will argue that such a "balance" is too obscure, others that this "balance" can be stated as a management objective. The complex nature of ecosystems makes the specificity implied by the term "balance" elusive.

Monnig and Byler (1992) suggested that pre-European settlement conditions in the Inland West could be used as a possible reference point for assessing the health of various ecosystem components. This historic range of variability is useful in understanding how ecosystems functioned in the recent past. However, that does not necessarily recommend the historic range of variability as a management goal.

Monnig and Byler (1992) said that judgments of forest health need to include information on ecosystem function as well as management objectives. Objectives must reflect limitations posed by ecosystem properties. They said "severe" outbreaks of insects and disease are sometimes signals that forests have "crossed ecological limits." In the end, the health of forests in the future will depend on management activities that promote the "natural" structure, composition, and function of ecosystems (Monnig and Byler 1992). Mlinsek (1991) agreed: "What we need is a forest where nature's properties are safeguarded when trying to manage the forest." Those properties are ecosystem components such as soil, water, trees, and animals, and ecosystem characteristics such as resistance and resilience.

Maintaining "natural" ecosystem properties is indeed an important consideration, if society determines this to be important for particular forests. The replacement of the word "natural" with "desired" would better

incorporate social concerns into forest health and ecosystem management discussions, and perhaps alleviate concerns some people express about distrust of professional authority associated with forest health and ecosystem management implementation programs.

MAJOR FINDINGS

The major findings contained in the complete report are summarized with the following points, taken from the conclusions of each chapter in the report. These findings are presented in the order they were developed in the report, and appear under the headings of the four parts of the complete report.

Towards a Definition of Forest Health

- Forest health is a condition of forest ecosystems that sustains their complexity while providing for human needs.
- Judgments about forest health involve different perspectives and values, including political, social, scientific, and professional. Because of these different viewpoints, forest health has subjective elements.
- In 1992, 85% of 801 randomly sampled Idahoans who were polled considered insect infestations and disease in Idaho forests a problem (Dan Jones and Associates 1992).
- Sustaining forest health is a principal focus of the evolving concept of ecosystem management.
- Forest health is concerned with a forest ecosystem, not just trees or stands of trees. But without trees, there is no forest.
- Ecosystem integrity is not currently a measurable concept, and therefore not useful to make judgments about forest health.
- A healthy forest is resilient. It has the ability to respond to natural and human-caused disturbances such as fire, insects, disease, climate change, air pollution, and timber harvesting, and recover to a socially desired state within a characteristic period of time.
- Forest health is a multi-disciplinary concept, rarely mentioned in forestry literature before 1990.
- Forest health is a useful communications device for relating forest conditions to something people understand, thus attracting their attention to management problems and inspiring them toward socially desired solutions.
- As is true in other health contexts, it may be easier to identify when a forest is unhealthy in one or more aspects than it is to define exactly what healthy means.
- Forest health focuses attention on: [1] the prevention of socially undesirable forest conditions by integrating the various concerns of protecting the forest from insects, diseases, and wildfires in an ecological framework; and [2] the restoration of socially desired forest conditions.

Management and Policy Considerations

- Many factors affect forest health, including natural and human-caused disturbances and variations in climate.
- Trees weakened by moisture stress are more susceptible to insects and diseases as well as wildfires. A 6-year drought that began in 1987 has affected Idaho forest conditions.
- The importance of the role of fire in Idaho's forests cannot be overstated. Idaho forests were formed and maintained by fire. Suppression has excluded fire from its historic role and led to changes in species composition and dense forest stands. In hindsight, fire suppression may not have been the best way to manage forests. However, the USDA Forest Service and other public agencies were directed to prevent and stop wildfires, and they performed this dangerous and challenging assignment very well.

- Salvage logging is useful for reducing fuel levels to protect remaining vegetation and soils from catastrophic wildfires, and recovering economic values. It does, however, need to be conducted under ecologically and socially acceptable guidelines. Some dead woody material needs to remain on site for wildlife habitat and soil development. Salvage logging on root-diseased sites may not be appropriate unless accompanied by reforestation of species less susceptible to root disease.
- Wildlife are a component of forest ecosystems. The direct use of wildlife as indicators of ecosystem health is difficult because of the diversity of wildlife species, their different habitat requirements, and lack of sufficient knowledge about these requirements.
- Forest health stands on its own as a concept, and is a goal of ecosystem management. Norris et al. (1993) said the condition of the forest landscape is the dominant focus of ecosystem management. Forest health, being the condition of a forest ecosystem, is thus a dominant focus of ecosystem management.
- Declining forest health, however measured, is a symptom of a problem. Treatment of the symptom may improve the condition of the ecosystem, but as in human health, it may not alleviate the cause of the problem.
- A healthy forest is sustainable, capable of meeting the socially-determined needs and aspirations of the present without compromising the ability to meet those of the future.
- Factors that predispose forests to pest outbreaks include tree species composition poorly suited or adapted to a site, overstocking, and old age. All of these risk factors can be reduced through management activities. Unless that is done, all ecological, economic, and social values associated with forests are at higher risk than need be.
- Additional research efforts focused on the development of hazard and risk rating systems would be useful to help managers determine which stands of trees need attention, and what management programs could help ensure sustainable forest ecosystems.
- Legislation at the national level has been introduced to address some of the forest health situations that have arisen in the Inland West. Additional funding and management flexibility to treat unhealthy conditions has been proposed. Such action may be necessary on some national forests.

Determining Forest Health Conditions

- Objective indicators of forest ecosystem condition can be specified and measured, but forest health assessments contain subjective value judgments which must be clearly recognized.
- Forest health can be measured, but at least three judgments need to be made: [1] selecting a representative set of indicators to measure ecosystem health—vegetation, wildlife, and watershed as a minimum; [2] developing standards for using indicator measures to assess conditions; and [3] resolving value conflicts regarding these judgments.
- Forest scientists and managers, working with their customers, can identify, define, and determine ranges of desired conditions for a set of measurable characteristics in each forest ecosystem. These measurements can be useful in helping evaluate the condition of the forest at any time, in relation to conditions desired by society.
- The presence of non-native vegetation and wildlife may be a key indicator of ecosystem condition.
- "Forests can be considered healthy when there is an appropriate balance between growth and mortality" (Norris et al. 1993).

- Comprehensive and intensive inventories of a few indicators representing commodity and non-commodity values will improve forest health assessments, as well as forest planning and management decisions, by enabling understanding of ecosystem characteristics of stands, habitats, streams, and landscapes.
- The species composition of trees in Idaho forests has changed. Ponderosa pine and western white pine were once predominant. Douglas-fir and grand fir are now the predominant species.
- Wood volume in Idaho forests increased by 12% between 1952 and 1987. Annual volume growth has been twice the annual timber harvest during that period.
- On the Boise and Payette National Forests in southwestern Idaho, forest stands identified as suitable for timber production were dying faster than they were growing in the late 1980s and early 1990s. Neighboring private industrial forests did not experience similarly high mortality rates.
- In northern Idaho, mature stands on the national forests are experiencing elevated levels of mortality from root disease. Inventories of private and other public lands do not indicate similarly elevated levels of mortality. However, the two different data sets are not directly comparable. Some attention to improved forest health inventory information seems necessary.

Towards a Forest Health Management Strategy

- To promote healthy forests throughout the state, management attention should focus on two things: [1] restoration of tree species best suited to each site, in most cases ponderosa pine, western larch, and rust-resistant western white pine; and [2] prevention of unhealthy conditions by maintaining stand density levels that reduce competition between trees for moisture, nutrients, or both.
- Thinning to alter species composition and reduce stand density is the most important part of a forest health management strategy. Root-diseased areas require different approaches.
- Formal plans for national forests have not adequately considered the impacts of insect, disease, and wildfire outbreaks in Idaho and subsequent actions necessary to sustain forest health and long-term productivity.
- The forestry profession is currently undergoing substantial changes. New planning approaches and management strategies are being developed to sustain the broad range of forest ecosystem values desired by society. These changes need the support of forestry professionals and forest owners, including the public, who collectively own more than three-fourths of Idaho's forests.
- Forests are in decline in Idaho, and because of the diverse nature of these forests, there is no single causal variable, and thus no easy fix. Forest health has promise as an integrating concept whereby scientists from different backgrounds can work together in support of management to sustain ecosystems while providing for the range of forest values society desires.
- The forest health research agenda includes silviculture, hazard rating and risk analysis, integrated inventories, and modeling. Special attention needs to be given to wildlife as indicators of forest ecosystem health.
- Forest health is related to ecosystem management. Much work still needs to be done to develop and implement ecosystem management, especially in the social dimension. In the end, only when forests are viewed from the larger landscape perspective that ecosystem management promises can multiple use be considered a feasible strategy.

ARE IDAHO'S FORESTS HEALTHY?

The suppression of wildfire has changed the composition of trees in Idaho. The high mortality rates in Idaho's national forests are a result of this shift.

Change in Idaho Forest Types

Idaho has 5 of the 22 major forest types in the United States recommended by the Environmental Protection Agency (Riitters et al. 1990) for monitoring to assess forest health. They are Douglas-fir (27.9% of the Idaho total), fir/spruce (27.6%), lodgepole pine (13.3%), ponderosa pine (9.6%), and western white pine (4.3%). These five forest types represent 82.7% of all Idaho growing stock volume (Benson et al. 1987).

Figure 3 illustrates changes in the composition of tree species in Idaho forests since 1952. The back row in Figure 3(a) shows that Douglas-fir has increased slightly, holding its position as the largest component of Idaho forests. Figure 3(b) shows Douglas-fir increased by roughly 1.2 billion cubic feet (top scale) or 15% (bottom scale). The second largest component is the aggregation for Engelmann spruce, western larch, and other softwoods, primarily western redcedar and western hemlock. Taken together, spruce, larch, cedar, and hemlock increased by more than 30% from 1952 to 1987. The next component depicted in the illustration is true firs, consisting mainly of grand fir but including subalpine fir and a small amount of white fir. The true fir component has increased by 60%. Lodgepole pine increased almost 40% during the 35-year period of analysis.

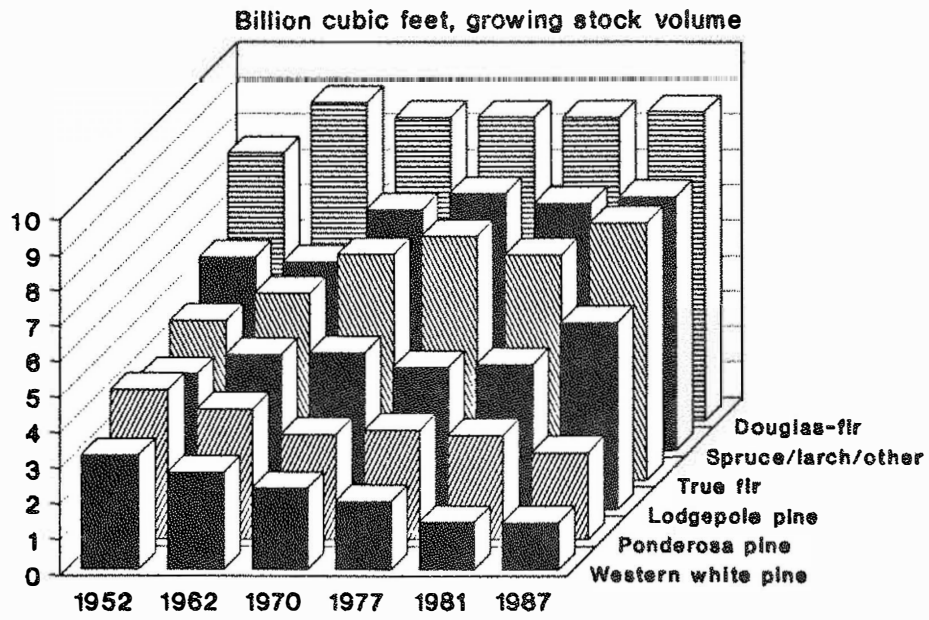
Historically, the most important timber species in Idaho were ponderosa pine and western white pine. Both have declined since 1952, ponderosa pine by 40% and western white pine by 60% (Figure 3). Byler et al. (1994) estimated that the extent of western white pine may now be only 10% of what it was in 1900.

Based on these species changes, it is obvious that something significant has happened in Idaho's forests. Ponderosa pine has been reduced because it is a desirable timber species. Through the combined effects of fire exclusion and timber harvesting, Douglas-fir has invaded sites once occupied by ponderosa pine. Western white pine, also a desirable timber species, has been reduced primarily by the introduction of the exotic white pine blister rust fungus in the region in the early 1900s.

Figure 3(b) depicts the same data in a different way, and shows that growing stock volumes of both western white pine and ponderosa pine have declined by almost 2 billion cubic feet from 1952 to 1987. During that period, the true firs increased about 2.7 billion cubic feet. Spruce, larch, and other softwoods increased approximately 1.7 billion cubic feet. Lodgepole pine and Douglas-fir have both increased more than 1 billion cubic feet.

Western white pine and ponderosa pine together have declined by almost 4 billion cubic feet, while true firs and Douglas-fir have increased by a like amount. The increases in lodgepole pine and other softwoods, therefore, represent about 3 billion cubic feet of net volume increase (or 12%) in Idaho's forests since 1952.

(a)



(b)

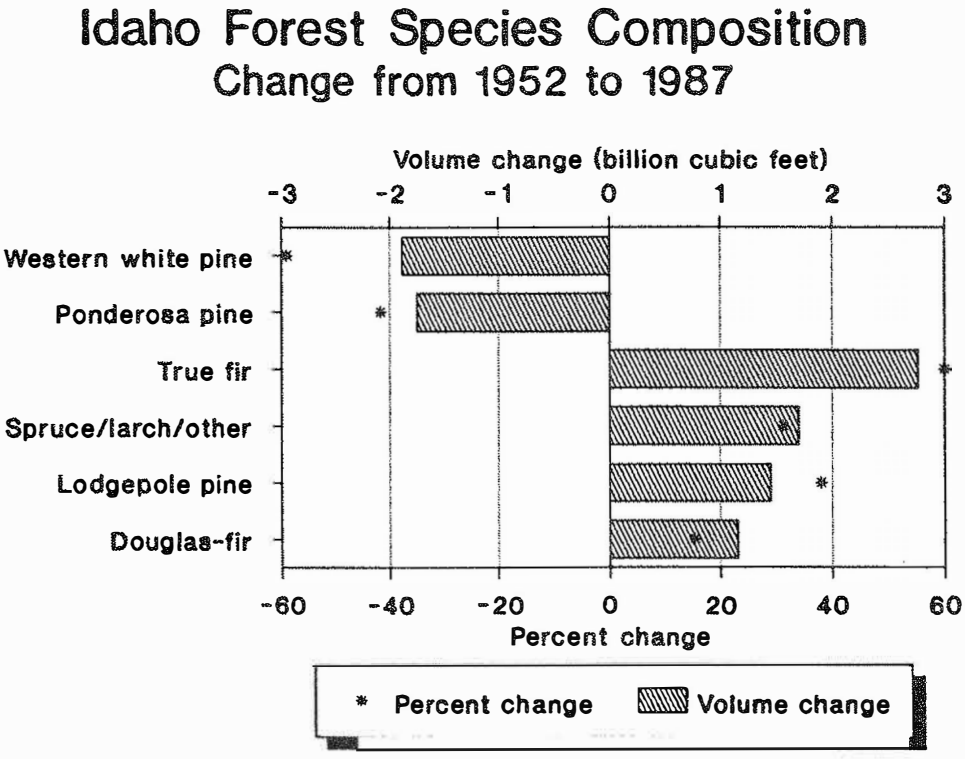


Figure 3. (a) Trends in Idaho forest tree species composition, 1952-1987; (b) with volume and percent changes by species.

Tree Growth and Mortality Analysis

Public concern about forest health in Idaho is greatest in southwestern Idaho. The reason for this is revealed by analyzing the growth and mortality data from forest plans for Idaho's national forests. Averaged across all ten national forests, mortality was 18.3% of gross annual growth, the measure of forest health suggested in a task force report of the Society of American Foresters on Sustaining Long-Term Forest Health and Productivity (Norris et al. 1993). Of the five national forests that have more than 2 billion cubic feet of growing stock volume, the Boise and Payette National Forests had, respectively, mortality at 31.3% and 24.9% of gross annual growth, well above the average. Of the five other national forests, the Targhee, with 1 billion cubic feet of growing stock volume, had mortality at 28.3% of gross annual growth.

The forest health situation on the Boise and Payette National Forests has worsened since the drought began in 1987, and is cause for concern, if not alarm. Our analysis, summarized in Figure 4, can be stated succinctly—trees in these forests are dying faster than they are growing. McGuire (1958) defined such situations as "catastrophic mortality." Most people would likely agree that such a high level of mortality is an unhealthy condition, but no standards for making that judgment have been developed. The condition of trees is an important feature of forest ecosystem health, but the complexity of ecosystems is such that soil, water, and wildlife components of forests might need to be considered.

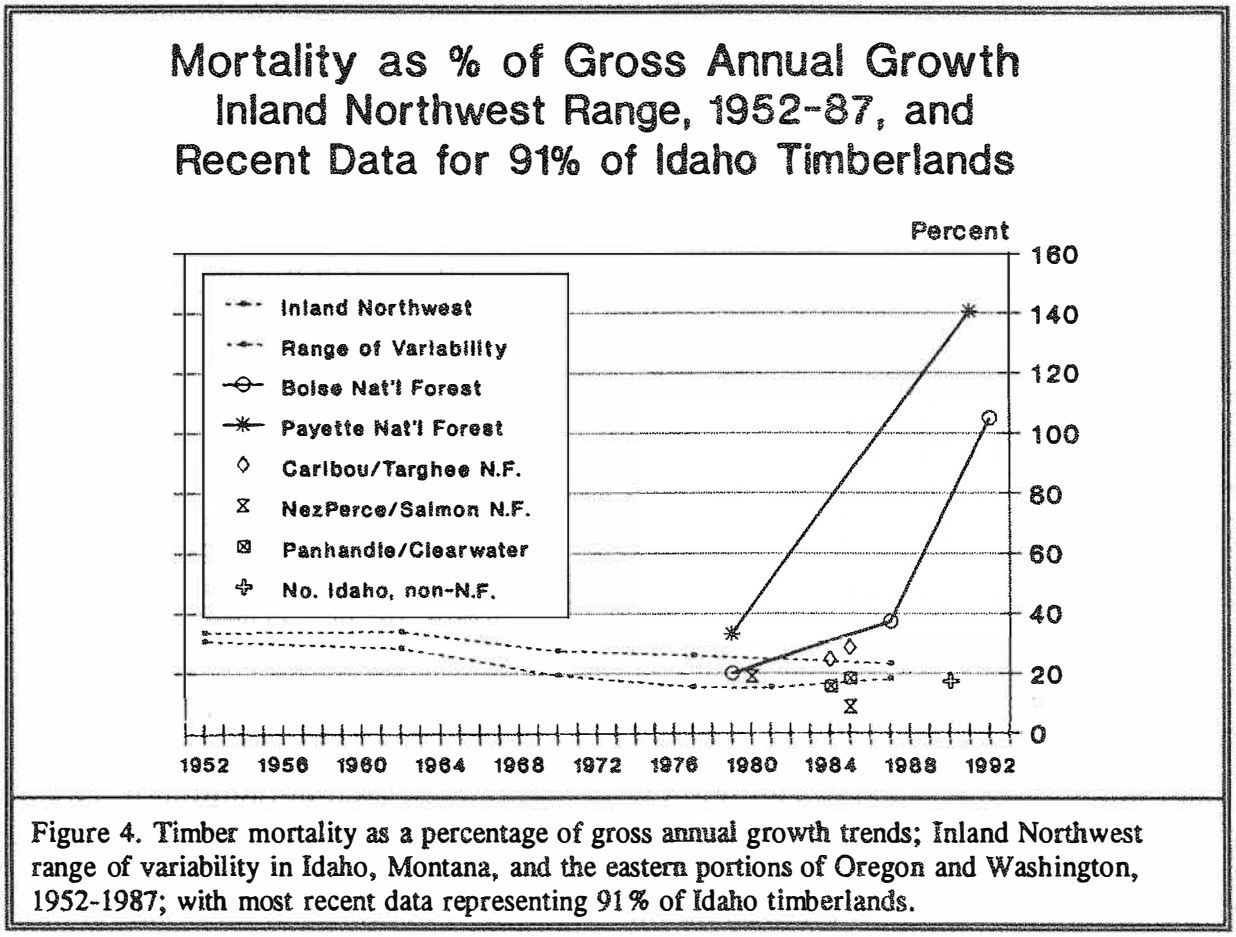


Figure 4. Timber mortality as a percentage of gross annual growth trends; Inland Northwest range of variability in Idaho, Montana, and the eastern portions of Oregon and Washington, 1952-1987; with most recent data representing 91% of Idaho timberlands.

Source: Adapted from USDA Forest Service (1958, 1965, 1973, 1982), Benson et al. (1987), Waddell et al. (1989), Waddell (1992), Wilson and Van Hooser (1993), and Payette National Forest and Boise National Forest inventory data and 1992 estimates furnished to the authors.

Figure 4 shows that the range of variability in this measure of mortality ranged from a low of 15% to a high of almost 35% across the Inland Northwest during periods of measurement at the statewide level from 1952-1987. By overlaying this range of variability in the region with data for Idaho forests, the results in Figure 4 reveal that the Boise National Forest was within the regional range in 1954 and 1979, and outside it in 1987 and 1992. The Payette National Forest was at the upper limit of the range of variability in 1979, and in 1991 was well beyond it, when mortality was 1.4 times gross growth. Mortality on the Caribou and Targhee National Forests was at 25% and 28% of gross growth in the mid-1980s, respectively, and just at the upper limit of the regional range. The Nez Perce National Forest was last inventoried in 1979, and showed no evidence of a problem. Nor did the Salmon, Idaho Panhandle, and Clearwater National Forests in the mid-1980s. Inventory data for 1990 on the 3.5 million acres of forests outside national forests in northern Idaho showed mortality as 17.1% of gross annual growth, well below the upper limit of the regional range for 1987 (Figure 4).

Is Mortality a Problem in Idaho Forests?

From the data that are available, tree mortality fell outside the regional range on the two national forests in southwestern Idaho (Figure 4). Both the Boise and Payette National Forests have recently experienced levels of mortality that exceeded gross annual growth. The forests also have declining gross annual growth, which also contributes to an unfavorable relationship between growth and mortality. To the extent that tree growth and mortality data reflect forest health, it may be said that the Boise and Payette National Forests both have a forest health problem on lands suited for timber production. If more current mortality data for some other Idaho national forests were available, it might be expected to reveal symptoms of forest health problems from the drought in southern Idaho and root disease in northern Idaho.

What about the rest of Idaho? Forests cover 41% of the state; timberlands are part of that, covering 28% of the state. Analysis of forest mortality conditions on all Idaho timberlands is provided in Table 1 and explained in the remainder of this section.

The area in southwestern Idaho represented by the Boise and Payette National Forests, and Boise Cascade Corporation lands that lie between them, are 19% of Idaho's timberlands. Boise Cascade's timberlands are not experiencing the same rate of forest mortality as the two neighboring national forests. The difference is explained by the management approaches of the organizations.

Another 28% of Idaho's forests are in the south central and southeastern portion of the state. Most of these timberlands are national forests, and inventory data for them are not current enough to compare with data from the Boise and Payette National Forests. Forest growth and mortality data from the mid-1980s indicated slightly elevated mortality/growth ratios on the Caribou and Targhee National Forests. The Bureau of Land Management has 3.8% of all Idaho timberlands, with two-thirds of them in southern Idaho. A recent inventory of BLM timberlands in southeastern Idaho revealed that 56% of the timber volume was "alive and healthy," 21% was infested with Douglas-fir bark beetle, and 23% was dead (USDI Bureau of Land Management 1992).

Most of Idaho's timberlands (53%) and forest volume (67%) are north of the Salmon River. The three national forests there represent 29% of the timberland base in the state, and 43% of the forest volume (Figure 2). The health of these forests is of major concern because of root disease problems (Hagle and Byler 1993). Soil and moisture conditions in northern Idaho are such that these are, as Wilson and Van Hooser (1993) said, among the most productive timberlands in the nation. But past management activities—fire exclusion and timber harvesting—and the introduction of white pine blister rust have changed the composition of these forests from pines to firs, with attendant management problems. Firs are adversely affected by root diseases, a natural component of northern Idaho forests that once acted, in

Table 1. Forest health conditions in Idaho.

Region and Ownership Category	% of Idaho Total		Forest Condition (expressed by forest growth and mortality)
	Timberland	Forest Volume	
Northern Idaho National Forests	29%	43%	No problem apparent in mid-1980s forest resource inventory data. Forest pathology surveys taken since 1985 indicate elevated levels of mortality in mature stands due to root disease and 40% reductions in productivity (S. Hagle and J. Byler, personal communication and unpublished papers).
Northern Idaho Other Public & Private Forests	24%	24%	No problem apparent in early 1990s forest resource inventory data.
Southwestern Idaho (mostly National Forests)	19%	15%	Annual mortality exceeds gross annual growth. On average, on suitable timberlands, forests are dying faster than they are growing on both the Boise and Payette National Forests. Intermingled industrial forests do not have similarly elevated mortality levels.
South Central and Southeastern Idaho (mostly National Forests)	28%	18%	The Targhee and Caribou National Forests had slightly elevated mortality/growth ratios in the mid-1980s. A recent inventory on BLM forests in southeastern Idaho showed high levels of mortality.
State of Idaho Total	100%	100%	Forests throughout southern Idaho are suffering elevated levels of mortality from forest structure problems (species composition and stand density) exacerbated by drought. National forests in northern Idaho have elevated mortality levels from root diseases that threaten long-term productivity; inventory data show other public and private forests do not have elevated mortality/growth ratios.

concert with wildfire, to limit the abundance and distribution of firs.

Recent forest inventory data is not available for other national forests comparable to that for the Boise and Payette National Forests. However, forest pathologists have been studying the root disease situation in northern Idaho since 1985, and their data reveal that mature forests throughout northern Idaho are experiencing very high mortality rates, averaging 3% to 4% in mature stands, which is well above the expected regional range of

0.5% to 0.7%. As a result, these forests have experienced 40% productivity loss (J. Byler and S. Hagle, personal communication; Byler et al. 1994).

Private and other public forests—that is, other than national forests—in northern Idaho represent 24% of Idaho's timberlands and forest volume. Recent inventory data for these forests do not indicate elevated levels of mortality (Wilson and Van Hooser 1993). This may be a result of different management practices on these lands than on the national forests, or different techniques for measuring mortality used by forest inventory personnel and forest pathology specialists, or both. More work is needed to ascertain the effect of root diseases on the productivity of northern Idaho forests and the effectiveness of management treatments in mitigating root disease effects.

Example of Productivity Loss

Preliminary modeling research results reported by Hagle and Byler (1993) indicate significant losses in future productivity in seral ponderosa pine forests in northern Idaho. (Seral refers to a biotic community that is in a developmental or transitional stage.) These projected losses, illustrated in Figure 5, result from the combined effects of fire exclusion, species conversion, and root disease.

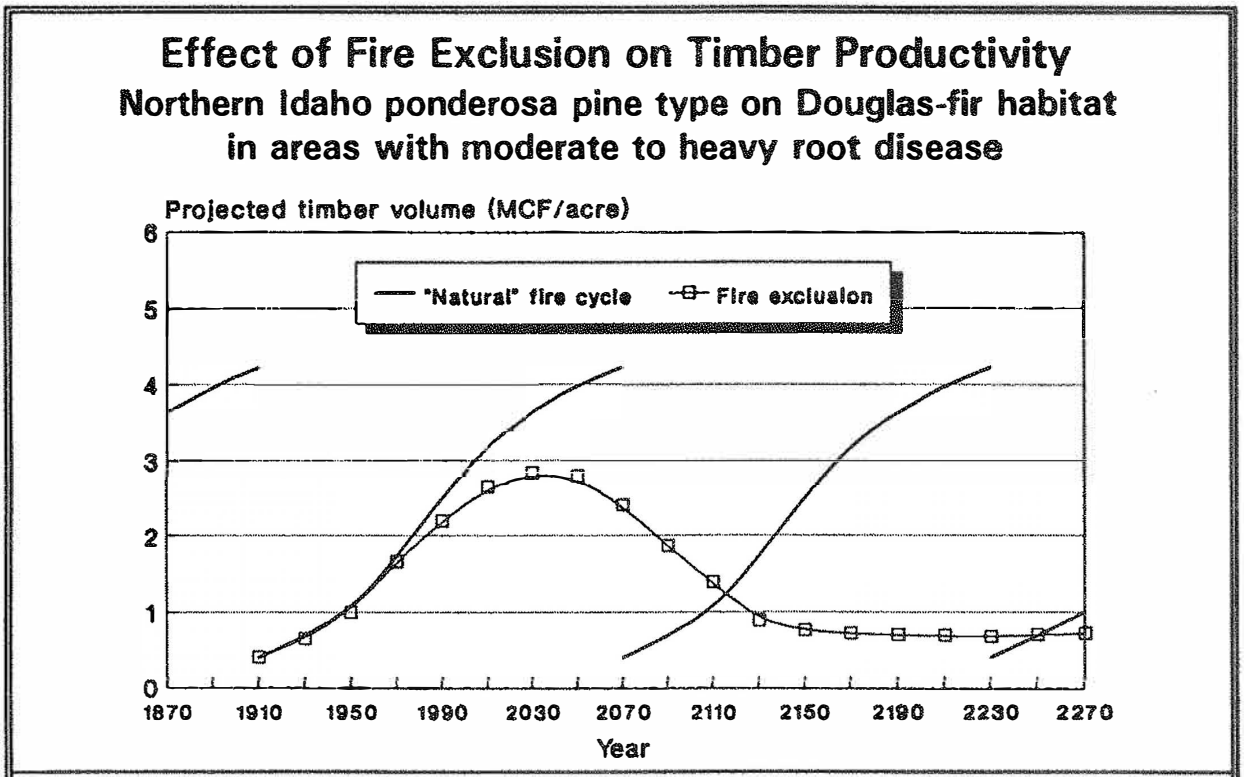


Figure 5. Effect of fire exclusion on timber productivity, northern Idaho ponderosa pine type on Douglas-fir habitat in areas with moderate to heavy root disease.

Source: Adapted from Hagle and Byler (1993).

The two fire regimes in Figure 5 are, first, a cycle of stand-replacing fires every 160 years (labelled "natural" fire cycle), with periodic low-intensity fires that favor ponderosa pine rather than Douglas-fir. This regime models "natural" fire frequencies and intensities. The second fire regime (labelled fire exclusion) is the end result of wildfire suppression. Seral ponderosa pine forests succeed to Douglas-fir without periodic low-intensity "thinning" fires.

Douglas-fir is chronically affected by root disease in northern Idaho.

The difference in productivity is projected to be dramatic. Figure 5 illustrates modeling results from what happens to two types of hypothetical stands established in 1910, when severe wildfires swept through more than two million acres of forests in northern Idaho. In 1990, the stands in which periodic low intensity fires were allowed to burn have 12% more timber volume on them than the stands where fire was excluded. By the time 160 years has elapsed and another stand-replacing fire may be expected (in the year 2070), the difference in productivity is 43%. By the time two such cycles have run their course (in the year 2230), the productivity loss from fire exclusion is a staggering 92%.

The projections in Figure 5 are based on measurements taken in 10 ponderosa pine stands on Douglas-fir habitat type where fire has not been suppressed and 10 similar stands where fire has been excluded. These are preliminary results by Hagle and Byler (1993) using the Prognosis growth projection model (Stage 1973, Wykoff et al. 1982) and a variant for root disease effects (Stage et al. 1990).

FOREST HEALTH MANAGEMENT ALTERNATIVES

Prevention of unhealthy conditions and restoration of healthy conditions are called for in Idaho's federally-managed forests. The causes of current forest conditions are known. Stand structure has been altered by timber harvesting and fire suppression. Fire no longer performs its natural role of controlling species composition and stand density. Before European settlers arrived in Idaho, fires established and maintained extensive pine stands, and those stands have now largely been replaced by firs. These stands are dense, increasing competition among individual trees. When limited moisture conditions occur, as during the recent drought, weakened trees are less resistant to insects and diseases, and prompt epidemic outbreaks as well as situations favoring catastrophic wildfires.

The solutions are known. Restoration of healthy conditions and prevention of unhealthy conditions involve management actions to alter species composition and stand density. Some species of trees are better adapted to certain site conditions than are others. Changing species composition by favoring the trees best adapted to a site (that is, those most resistant to insect and disease disturbances) is an obvious solution. On many sites in Idaho, that will mean ponderosa pine, western larch, and rust-resistant western white pine instead of Douglas-fir and grand fir. Species composition is especially important on sites affected by root diseases.

Stand density control and species composition changes can be achieved by intensive management practices. Thinning the number of trees on a site to reduce competition for limited moisture or nutrients is appropriate on many sites. This involves either felling some selected trees and removing them, or restoring the role of fire through prescribed burning, or both. The risk of catastrophic wildfire can be reduced by thinning and by removing dead trees. Risk of insect and disease epidemics may be reduced in some cases by removing dead or dying trees. On sites affected by root disease, species composition changes are also called for, and in some cases may require regeneration practices.

Forest health and forest ecosystem management are part of the "sustainability" value associated with forests. Forests are defined by trees, however soil, water, wildlife, and other values need to be part of forest health management. To prevent unhealthy forests, managers will need to think in terms of curing the underlying cause rather than merely treating the symptoms of unhealthy conditions. Such management requires a long-term view of how ecosystems function across large areas of the landscape. Ecosystem dynamics mean that particular structural conditions can be perpetuated or sustained only at a very large, or landscape, scale.

The objectives for and uses of a particular forest need to be decided by people. Objectives have to be set within the physical and biological capability of the ecosystem. Achieving a healthy and sustainable forest

ecosystem may become a stated objective of forest managers, but sustainable and healthy ecosystem goals will not define the uses for a particular area. Those uses need to be consistent with management objectives, and attainment of desired ecosystem conditions. The related concepts of forest health and ecosystem management will not make the job of forest managers any easier. The concepts are new and the goals are far more complex than before. Forest health and ecosystem management put management tasks in a different and broader context. These tasks will require the development and application of new ideas and tools, such as landscape-level management, and new approaches for involving people to determine forest management objectives and desired forest conditions.

Forest Management Strategies

At least five forest management strategies are available: intensive and extensive forestry (both are variations of the traditional forestry approach), adaptive forestry, ecosystem management, and no management. Idaho is endowed with tremendous forest wealth, and there are appropriate places for all five types of management across the different types of forest ownerships in the state. The choice is a function of the objectives of the forest landowner made within the bounds of public policies affecting forestry. The strategies differ as follows.

Intensive forestry. This forest management strategy aims to sustain a high volume and quality of timber by applying the most appropriate management techniques and silvicultural practices. High levels of capital and labor inputs are used, with environmental concerns operating as constraints.

Extensive forestry. This strategy involves low level applications of operating and investment costs to a forest property. However, the Idaho Forest Practices Act ensures that minimum reforestation and water quality standards are maintained.

Adaptive forestry. This type of forest management is capable of adapting to social changes and demands on the forest; of adapting to characteristics of the ecosystems and sites where it is applied; of adapting to new scientific knowledge and techniques; and of adapting to new conditions yet to be experienced, such as global climate change, drought, fire, etc. By maintaining diverse and fully functional ecosystems, both management and the forest can adapt and respond (Adams 1992).

Ecosystem management. This strategy is now the underlying philosophy of federal forest management. It arose from the USDA Forest Service's "New Perspectives" program in the early 1990s. A universally accepted definition has not been developed. Ecosystem management involves managing forests to provide a diversity of ecosystem types and states in a mosaic pattern across a large-scale landscape (probably at least 100,000 acres), allowing for production of commodities and other services consistent with socially-determined goals describing desired forest uses and conditions.

Ecosystem management is related to adaptive forestry described above. It offers to private and other public ownerships intermingled with federal forests whatever advantages are associated with coordinated planning. These advantages could include (a) coordinated analysis of cumulative watershed effects for compliance with the Clean Water Act of 1987, and (b) the possibility of extending consultations for endangered species incidental take permits to private forest owners and state agencies. These permits are available to federal agencies (but to no one else) through the process of interagency consultation under section 7 of the Endangered Species Act of 1973.

No management. No timber harvesting or forestry activities are undertaken, including in some cases no wildfire control. The underlying assumption is acceptance of whatever consequences may arise from the operation of ecological processes.

If an ecosystem health problem arises, no

management is akin to what philosopher Eugene Hargrove (1992) called "therapeutic nihilism"—a term used to describe the mid-19th century notion that because the cure can be worse than the disease, nature knows best. This idea is sometimes invoked in nature preservation arguments today (Hargrove 1992).

Does nature know best when it comes to managing ecosystems? Ecologist Daniel Botkin said, "When you do nothing, you'll get something you didn't expect" (Kaufmann 1993).

Forest Health, Management Strategies, and Ownership Objectives

All forest ecosystem values, whether environmental, ecological, economic, or social, are related to the condition or health of trees. The question whether forest owners should promote healthy forest conditions—or, more pragmatically, avoid unhealthy conditions—is directly related to their management objectives. If owners decide their forests should be healthy, stands of trees can be managed to provide goods and services for human needs while avoiding unhealthy conditions. This can be done under any of the strategies described above, except the no management alternative.

Private and "other" public forests. Industrial forests, many other private forests, and most state forest lands in Idaho are managed primarily for timber production. Unhealthy forests (however defined) are undesirable because present and future economic values are placed at risk. Intensive management practices are used routinely on private industry and state forest lands to reduce the risk of insect, disease, and wildfire losses.

Non-industrial private forest landowners are likely to follow the extensive management strategy, perhaps because they perceive forest health management costing them money. However, thinning can more than pay its own way, depending on the size of trees to be thinned.

The University of Idaho follows adaptive management strategies on the College of Forestry, Wildlife and Range Sciences Experimental Forest near the Moscow campus.

National forests. The majority of Idaho's forests are in the National Forest System managed by the USDA Forest Service (Figure 2). Management objectives and goals for the national forests are matters of national public policy. Forest health considerations for four types of land area classifications need to be considered in the national forests: [1] designated wilderness and other areas legally or administratively reserved from timber harvest, [2] areas identified as unsuitable for timber production, [3] roadless areas identified as suitable for timber production, and [4] roaded areas identified as suitable for timber production.

[1] Wilderness areas.—In designated wilderness areas, an argument can be made that nature should prevail, and insects, diseases, and wildfire allowed to operate so scientists can better understand natural processes. However, fire suppression over many decades weakens the argument that Idaho wildernesses are natural systems. Nonetheless, most patches of dead trees or burnt-over areas in wilderness will eventually support the vegetation and associated values that were once there.

A dilemma arises. Although the appearance of wilderness is not particularly relevant when viewed from a scientific perspective, scenic values of wilderness are also recognized in the Wilderness Act of 1964, and research supports the proposition that people don't like the looks of dead trees. Trail maintenance is performed to protect wilderness resource values, and in some cases maintenance of forest health may be appropriate for protecting the full range of wilderness values.

Another dilemma is that sometimes natural forces can overwhelm human efforts to control them, and wildfire, insects, and diseases can spread from wilderness to adjacent lands. Although intensive forestry practices may be antithetical to the wilderness concept, there is a provision in the Wilderness Act (section 4 (d)(1)) that allows "such measures as may be

necessary in the control of fire, insects, and diseases, subject to such conditions as the Secretary deems desirable." The economic and social costs associated with large and intensive wildfires are widely recognized as undesirable, and argue against the no management alternative, even in wilderness areas.

[2] Areas "unsuited" for timber production.—In national forest areas not suitable for timber production, other resource values—watershed, wildlife, forage, recreation, and aesthetics—argue against allowing wildfire, insects, and diseases to run their course. Indeed, many of these areas are unsuitable for timber production because watershed protection and wildlife habitat values were recognized as greater than timber production values. Together with wilderness areas, these "unsuited" lands represent 61% of all national forest lands in Idaho (Table 2). These lands will likely never be scheduled for timber production.

There are dilemmas, however. Watershed health (however defined) will benefit from healthy forested riparian buffer strips. Some forest management practices may be necessary to protect buffer strips, particularly those designed to reduce fire hazards that can affect watershed health. Wildlife habitat may also be enhanced by certain forest management practices.

[3] Roadless areas "suited" for timber production.—Unroaded areas in the national forests identified as suitable for timber production spark much of the controversy regarding forest health. There are 9.4 million acres of national forest roadless lands in Idaho, and some wilderness advocates would like to see the majority of these lands added to the National Wilderness Preservation System (see MacCracken et al. 1993). Forestry practices undertaken for any reason in roadless areas, including forest health, are therefore likely to be challenged.

Because 2.1 million acres of roadless areas have been identified in forest plans as suitable for timber production (LeVere et al. 1991, Table 2), it can be argued that these forests should be maintained in healthy and productive conditions, meaning timber values on these lands should be protected. These areas represent 10% of all national forest lands in Idaho and 14% of all Idaho timberlands (Table 2). Roadless areas were identified by interdisciplinary teams as suitable for timber production and considered as such in public participation activities during the planning process.

We do not propose to settle the contentious arguments regarding Idaho's roadless areas, but suggest that some forestry practices may be appropriate in high risk areas. For example, a prescribed burning program to promote forest health could be implemented without jeopardizing wilderness suitability.

[4] Roaded areas "suited" for timber production.—National forest roaded areas identified in forest plans as suitable for timber production cover 5.9 million acres, or 29% of the national forests in Idaho and 41% of Idaho timberlands (Table 2). Healthy and productive forests are appropriate goals for these lands. When these forests are unhealthy (however that is measured) some creative management policy solutions may be needed to overcome the inflexibility of forest plans that did not provide for such contingencies. The appropriate course of action on these lands involves intensive forest management practices including thinning, prescribed burning, and regeneration of species best suited to the site.

Controversies regarding forest health have arisen because it is possible in some cases to exclude sales of dead timber from environmental analysis and administrative appeals, thus drawing angry responses from environmentalists. Too often, discussions of forest health have been reduced to arguments about salvage logging.

What About Salvage Logging?

Dead trees provide benefits affecting many forest values. Too many dead trees can threaten the very same values. Standing dead trees provide homes for woodpeckers and other forest denizens. When they fall, dead trees build soil and in some locations provide instream habitats. Dead trees, however, create the potential for catastrophic wildfires, which

Table 2. Possible forest health management strategies on national forest land area classifications.

National Forest Land Classification	National Forest Lands		National Forest Timberland as % of Idaho Total	Forest Health Management Strategy
	Acres	% of Total		
Wilderness, designated	4,037,270	20.0%	0% (a)	Control wildfire, and possibly insects and diseases, to prevent spread to adjacent lands and protect the full range of wilderness values—recreational, scenic, scientific, educational, conservation, and historical use.
Wilderness, recommended	1,292,006	6.4%	(b)	
Unsuitable for timber production	6,941,043	34.3%	12% (c)	Control wildfire, and possibly insects and diseases, to prevent spread to adjacent lands. Forestry practices are inappropriate for enhancing timber production, but may be appropriate for protecting and enhancing wildlife, watershed, and scenic values.
Roadless: suitable for timber production	2,066,500	10.2%	14%	Control wildfire, and possibly insects and diseases, to prevent spread to adjacent lands. Prescribed burning (and possibly salvage logging and thinning by helicopter) may be appropriate to promote forest health and other values placed at risk by unhealthy forest conditions, without jeopardizing wilderness suitability.
Roaded: suitable for timber production	5,886,943	29.1%	41%	Control wildfire, and possibly insects and diseases, to prevent spread to adjacent lands. Forest health can be restored, and unhealthy conditions prevented, by using intensive forestry practices. These include thinning, prescribed burning, fertilization, and regeneration of resistant and resilient species—especially genetically improved varieties. Intensive forestry is preferable to extensive forestry for promoting healthy forests in many situations. If healthy and sustainable forest ecosystems are a desired goal, intensive practices can be compatible with ecosystem management, especially with an adaptive management strategy.
All national forest lands	20,223,762	100%	67%	Keeping forest lands in healthy condition is an appropriate strategy to sustain forest ecosystems.

(a) 3,051,000 acres of forest land that meet the physical definition of timberland have been legally or administratively reserved and are no longer subject to timber harvesting or considered as timberlands.

(b) Acreage and percentage undetermined, but included in "unsuitable for timber production" percentage.

(c) 1,751,557 acres of "unsuitable" and "recommended wilderness" lands are classified as timberlands.

can negatively influence wildlife, watersheds,and scenery as well as vegetation. When done with sensitivity to social, environmental, and ecological concerns, a case can be made for salvage logging based solely on the ecological argument of fuel management to protect resource values. This argument also has an economic dimension, because preventative treatment to reduce fuels can reduce sub-sequent costs of wildfire control. The re-covered economic value of salvaged timber is a side benefit, but should not be overlooked. In Idaho, dead timber salvaged from national forests has been considered to be part of the allowable cut. Although it has become a focal point in forest health debates, salvage logging is only one part of a forest health management strategy.

The real issue is how to sustain a socially-determined array of forest ecosystem values. That is the rationale for keeping Idaho's forests healthy—especially the national forests that belong to every citizen of Idaho and the nation.

Relationship of Executive Summary to Complete Report

This Executive Summary of Report No. 11, Forest Health Conditions in Idaho, is published separately from the complete report, which consists of 17 chapters and exceeds 200 pages. This Executive Summary appears in the complete report as **Chapter 1. Summary and Overview.** Figure 3 and 5 in this Executive Summary appear in later chapters in the complete report. Cross references to the 17 chapters in the complete report have been deleted in this Executive Summary. A condensed version of the Table of Contents to the complete report is included in this Executive Summary as an **Appendix.** The complete report is available from the University of Idaho's Forest, Wildlife and Range Policy Analysis Group, Moscow, ID (208-885-5776; FAX: 208-885-6226), as are the reports listed on the inside cover.

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GLOSSARY

(Note: terms in **boldface** are defined elsewhere in the Glossary.)

Adaptive forestry. The University of Idaho term for forest management, the principal concept of which is **ecosystem sustainability**. A dominant characteristic is diversity: **landscape** diversity from the variety and distriburtion of management practices across the land and diversity of **ecosystem structure** of canopy layers and species variety in individual forest units. Such diversity fosters full **ecosystem function** (Adams 1992).

Adaptive management. Establishing measurable objectives, using the best knowledge to prescribe practices, monitoring the results, and adjusting practices as needed to meet objectives (Norris et al. 1993).

Allowable sale quantity (ASQ). The quantity of timber that may be sold from an area of suitable land covered by a **Forest Plan**, for a time period specified by the Plan. This quantity is usually expressed as the "average annual allowable sale quantity" (Gast et al. 1991).

Annual mortality. The volume of sound wood in trees that died from natural causes during a specified year (USDA Forest Service 1990).

Catastrophic pest-caused damage (losses). A level of insect- or disease-caused tree **mortality** and/or damage, such that resource management goals or objectives are significantly hindered, and **Desired Future Condition** described in **Forest Plans** cannot be achieved in either the short-term or the long-term (Gast et al. 1991).

Climax. The culminating stage in plant **succession** for a given site where the vegetation has reached a highly stable condition, and is capable of reproducing in competition and persisting without disturbing influence (Gast et al. 1991).

Climax species. Those species that dominate a forest **stand** in either numbers per unit area or biomass at **climax** (Gast et al. 1991).

Complexity, ecosystem. As part of the **forest health** definition, includes spatial and temporal scales; that is, differences attributable to different space and time considerations.

Desired Future Condition. 1. A term used to reflect the hoped-for results to be achieved through the implementation of the **Forest Plans** in both the short- and long-term (Gast et al. 1991). 2. A deliberated outcome for a **landscape** that will sustain ecological conditions and meet human needs, now and in the future (USDA Forest Service 1993a).

Drought. A moisture unbalance which occurs when loss of water through foliage exceeds uptake of water. It may arise from one or more of the following: Inadequate soil moisture, excessive transpiration, restrictive rooting, or deficient root activity (Gast et al. 1991). See also the discussion and definition in the "Precipitation trends" section of Chapter 14.

Ecological health. Both the occurrence of certain attributes that are deemed to be present in a healthy, **sustainable** resource, and the absence of conditions that result from known stresses or problems affecting the resource (Palmer et al. 1992, after Rapport 1989).

Ecoregion. An area (region) of relative homogeneity in ecological systems (Gallant et al. 1989). Climate and vegetation type are characteristics used to differentiate these areas (Palmer et al. 1992).

Ecosystem. 1. An interacting system of organisms considered together with their environment; e.g., marshes, watersheds, and lakes are ecosystems (Gast et al. 1991). 2. Any complex of living organisms with their environment, that we isolate mentally for the purposes of study (SAF 1983). 3. A set of interacting species and their local, nonbiological environment, functioning together to sustain life (Botkin 1990). 4. A complex of interacting subsystems which persists through time due to the interactions of its components (Reichle et al. 1975). 5. A local complex of interacting plants, animals, and their physical surroundings which is generally isolated from adjacent systems by some boundary, across which energy and matter move; examples include a **watershed**, an **ecoregion**, or a biome (Palmer et al. 1992). See also **complexity, ecosystem.**

Ecosystem function. Attributes of the rate of change of structural components of an ecosystem; examples include primary productivity, denitrification rates, and species fecundity rates (Palmer et al. 1992). See also **ecosystem structure.**

Ecosystem management. 1. "By ecosystem management, we mean that an ecological approach will be used to achieve the multiple-use management of the National Forests and Grasslands. It means that we must blend the needs of people and environmental values in such a way that the National Forests and Grasslands represent diverse, healthy, productive, and **sustainable ecosystems**" (Dale Robertson 1992, Chief of the USDA Forest Service). 2. "We're still defining what ecosystem management consists of. But most importantly, the Pacific Northwest is serving as a laboratory to see how ecosystem management might be implemented" (Jim Lyons, 1993, Assistant Secretary of Agriculture for Natural Resources and Environment; see Hopps 1993). 3. The five volume set of documents called the "Eastside Forest Ecosystem Health Assessment" issued by the USDA Forest Service in mid-1993 (see Everett et al. 1993) contained three definitions of ecosystem management:

(a) The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or **sustain** ecosystem integrity and desired conditions, uses, products, values, and services over the long term (Volume II - Ecosystem Management, Principles and Applications).

(b) The conservation and use of natural resources to maintain biological diversity, long-term site productivity, and **sustainable** resource production and use; the new management paradigm on National Forests (Volume III - Assessment).

(c) A system of making, implementing, and evaluating decisions based on the ecosystems approach, which recognizes that ecosystems and society are always changing (Volume V - A Broad, Strategic Framework for Sustainable-Ecosystem Management).

Ecosystem structure. Attributes of the instantaneous state of an **ecosystem**; examples include species population density, species richness or evenness, and standing crop biomass (Palmer et al. 1992).

Endemic. 1. Restricted to, and constantly present in, a particular locality (Gast et al. 1991). 2. Of an organism confined, in its indigenous occurrence, to a particular region. 3. Applied to populations of potentially injurious plants, animals or viruses that are at their normal, balanced level, in contrast to **epidemic** (SAF 1983).

Epidemic. 1. Prevalent and spreading rapidly; widespread. Often used in reference to a rapidly increasing and spreading population of insects (Gast et al. 1991). 2. Of populations of plants, animals, and viruses that build up, often rapidly to lightly abnormal and generally injurious levels (SAF 1983). Contrasts with **endemic.**

Extensive forestry. The practice of **forestry** on a basis of low operating and investment costs per acre (SAF 1983). Contrasts with **intensive forestry.**

Forest health. 1. No widely accepted definition exists (Riitters et al. 1990). 2. A condition of forest **ecosystems** that **sustains** their **complexity** while providing for human needs (see Chapter 5).

Forest land. Land at least 10% stocked by forest trees of any size (USDA Forest Service 1990).

Forest management. 1. Generally, the practical application of scientific, economic and social principles to the administration and working of a forest estate for specified objectives. 2. More particularly, that brach of **forestry** concerned (a) with the over-all administrative, economic, legal and social aspects, and (b) with the essentially scientific and technical aspects, especially **silviculture, forest protection** and forest regulation (SAF 1983).

Forest Plan. (See **National Forest Land and Resource Management Plan**).

Forest protection. That branch of **forestry** concerned with the prevention and control of damage to forests arising mainly from the action of man (particularly unauthorized fire, grazing and browsing, felling, fumes, and smoke) and of pests and pathogens, but also from storm, frost, and other climatic agencies (SAF 1983). Note that wildfire is excluded from the definition. Those activities are termed fire pre-suppression, suppression, or prevention, or in the case of fuels, treatment to reduce fire threat or spread, fire **hazard** reduction (SAF 1983).

Forest type. A classification of forest land based upon the species presently forming a plurality of the live-tree **stocking** (USDA Forest Service 1990).

Forestry. The science, the art and the practice of managing and using for human benefit the natural resources that occur on and in association with forest lands (SAF 1983, this definition was adopted by the Society of American Foresters in 1967).

Growing stock. A classification of timber inventory that includes live trees of commercial species meeting specified standards of quality or vigor. Cull trees are excluded. When associated with volume, includes only trees 5.0-inches dbh [diameter class] and larger (USDA Forest Service 1990).

Habitat type. An aggregation of units of land capable of producing similar plant communities at **climax** (SAF 1983).

Hazard. 1. A state that may result in an undesired event; the cause of **risk** (Palmer et al. 1992). 2. Probability of tree **mortality** or damage by an insect or disease (Gast et al. 1991). 3. In fire prevention—the objective of which is to reduce the number of human-caused fires—it is the material or fuel that will ignite or burn (Barney et al. 1984). See also **forest protection**.

Health. See **ecological health** and **forest health**.

Indicator. A characteristic of the environment that, when measured, quantifies the magnitude of stress, habitat characteristics, degree of exposure to the stressor, or degree of ecological response to the exposure (Palmer et al. 1992).

Intensive forestry. The practice of **forestry** so as to obtain a high level of volume and quantity of output per unit of area, through the application of the best techniques of **silviculture** and management (SAF 1983). Contrasts with **extensive forestry**.

Landscape. 1. The fundamental traits of a specific geographic area, including its biological composition, physical environment, and anthropogenic or social patterns (Palmer et al. 1992). 2. A diverse land area of biological communities and physical features interacting with one another (Washington Forest Protection Association 1993). 3. At the landscape level, a size of 100,000 to 1,000,000 acres in suggested for perspective, but this point requires discussion and resolution within the forestry profession (Norris et al. 1993).

Landscape ecology. The study of the distribution patterns of communities and **ecosystems**, the ecological processes that affect those patterns, and changes in pattern and process over time (Forman and Godron 1986).

Long-term productivity. The capability of the land to support sound **ecosystems** which produce resources such as forage, timber, wildlife, and water (Gast et al. 1991).

Monitoring. A process used to collect significant data from defined sources to identify departures or deviations from expected **Forest Plan** outputs (Gast et al. 1991).

Mortality. The net volume of **growing-stock** trees that have died from natural causes during a specified period (Benson et al. 1987). See also **annual mortality**.

National Forest Land and Resource Management Plan. A Plan which "... shall provide for multiple use and **sustained yield** of goods and services from the National Forest System in a way that maximizes long-term net public benefits in an environmentally sound manner" (Gast et al. 1991). Forest Plans are required by the **National Forest Management Act**.

National Forest Management Act (NFMA 1976). A law passed in 1976 as an amendment to the Forest and Rangeland Renewable Resources Planning Act, requiring the development of Regional Guides and **Forest Plans** and the preparation of regulations to guide that development (Gast et al. 1991).

Net annual growth. The net increase in the volume of trees during a specified year. Components include the increment in net volume of trees at the beginning of the specific year surviving to its end, plus the net volume of trees reaching the minimum size class during the year, minus the volume of trees that died during the year, and minus the net volume of trees that became cull trees during the year (USDA Forest Service 1990).

Old-growth forest. A forest condition defined by age-class of vegetation, structure of forest canopy, volume of dead and downed wood debris, and other attributes; old-growth is trees, other vegetation, birds, mammals, and other organisms and the manner in which they associate and interact in communities. No single measurement, such as age, is sufficient to describe it (Franklin et al. 1981).

Other forest land. Forest land other than **timberland** and **reserved timberland**. It includes unproductive forest land, which is incapable of producing annually 20 cubic feet per acre of industrial wood under natural conditions because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness. It also includes urban forest land, which due to its location is unavailable for **sustained** timber harvesting (USDA Forest Service 1990).

Rehabilitation. Management activity to allow establishment of desirable tree species (usually more valuable, faster growing, or more pest resistant species) in existing **stands** that have been severely damaged by insects and diseases, or have deteriorated due to a variety of factors (Gast et al. 1991).

Reserved timberlands. Forest land that would otherwise be classified as **timberland** except that it is withdrawn from timber utilization by statute or administrative regulation (Waddell et al. 1989).

Restoration. See **rehabilitation**.

Risk. The probability of an undesirable event occurring within a specified period of time (Gast et al. 1991). In reference to fire prevention—the objective of which is to reduce the number of human-caused fires—it is those things or events that cause fires to start, including the actual igniting agents (matches, hot metal, etc.) and the people who may manufacture, use or handle those agents (Barney et al. 1984). In regard to insect populations, risk or risk-rating may contain components to evaluate the likelihood of an outbreak, the likelihood of trees being attacked (susceptibility), or the likelihood of trees being damaged (vulnerability) (Gast et al. 1991). See also **hazard**.

Salvage. The recovery of salvable dead trees, which are downed or standing and considered currently or potentially merchantable by regional standards (USDA Forest Service 1990).

Sawtimber trees. Live trees of commercial species containing at least one 12-foot sawlog or two noncontiguous 8-foot logs, and meeting regional specifications for freedom from defect. **Softwood** trees must be at least 9.0 inches dbh, and hardwood trees must be at least 11.0 inches dbh (USDA Forest Service 1990).

Seral. A biotic community that is in an early developmental, transitory stage in an ecological **succession** (Gast et al. 1991).

Seral species. A plant species characteristic of an early age in the development of a forest community; not permanent (Gast et al. 1991). See also **climax**.

Silviculture. The theory and practice of controlling the establishment, composition, constitution, and growth of forests (Gast et al. 1991, from SAF 1983).

Softwood. A coniferous tree, usually evergreen, having needles or scalelike leaves (USDA Forest Service 1990).

Stand. A community, particularly of trees, possessing sufficient uniformity as regards composition, constitution, age, spatial arrangement, or condition, to be distinguishable from adjacent communities, so forming a **silvicultural** or management entity (SAF 1983).

Stand density. A quantitative measure of tree **stocking**; more precisely, a measure of the degree of crowding of trees (SAF 1983).

Stocking. The degree of occupancy of land by trees, measured by basal area and/or number of trees by size and spacing, compared to a stocking standard; i.e., the basal area and/or number of trees required to fully utilize the growth potential of the land (USDA Forest Service 1990).

Succession (ecological). The process of development (or redevelopment) of an **ecosystem** over time (Botkin 1990).

Suitable forest land. Land to be managed for timber production on a regulated basis (Gast et al. 1991). Also termed suitable or suited timberland, these are national forest lands identified during the development and publication of a **National Forest Land and Resource Management Plan.**

"Suited" land. See **suitable forest land.**

Sustainability. 1. Resource sustainability requires a long-term balance between renewability and use that ensures the continuing productively of the resource (Frederick and Sedjo 1991). 2. In the context of **ecosystem management**, it has been defined as the balanced relationship between healthy ecological systems in a landscape and the needs of humans to maintain a quality lifestyle (USDA Forest Service 1993a).

Sustainable. Sustainable [resource] management implies using resource flows from existing stocks without seriously compromising the renewability of the resource for future use (Frederick and Sedjo 1991).

Sustainable ecosystem. Much talked about but hard to define. 1. Botkin (1990) implies that an **ecosystem** is **sustainable** by definition (see **ecosystem**). 2. Sustainable **ecosystems** are the integration of social expectations with land potentials, technology, and economic factors. The sustainability of ecological systems is defined by the historical range in **variability** of **ecosystem** patterns and processes at multiple hierarchial scales (Everett et al. 1993).

Sustained yield (management). The yield that a forest can produce continuously at a given intensity of management. NOTE: therefore implies continuous production so planned as to achieve at the earliest practical time a balance between increment (increase in tree volume or other measure in a given time period) and cutting (SAF 1983).

Thinning. A felling made in an immature **stand** in order to accelerate diamter increment but also, by suitable selection, to improve the average form [and condition] of the trees that remain (SAF 1983).

Timberland. Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood in natural **stands**. Currently inaccessible and inoperable areas are included.) (USDA Forest Service 1990). See also **reserved timberland**.

"Unsuited" land. See **suitable forest land**.

Variability. The flux in composition, structure, and function of an **ecosystem** over the long term in a **landscape** is a definition of variability. In the historic context it describes natural disturbance and human interaction as a trend through time (USDA Forest Service 1993a).

Watershed. The drainage basin contributing water, organic matter, dissolved nutrients, and sediments to a stream or lake (USDA Forest Service 1993c).

APPENDIX

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(condensed version as it appears in the complete report)